

Coating Systems

MDS-PRAD

Presentation to



ADUSD

Maintenance Policy,
Programs and
Resources



4 March 2005

- * Introduction / Background**
- * Current Fleet & T&E Programs**
- * Readiness & Cost Avoidance**
- * Coating Facility Status**
- * Other Engine Coating Opportunities**

“The Problem”



“The Problem”

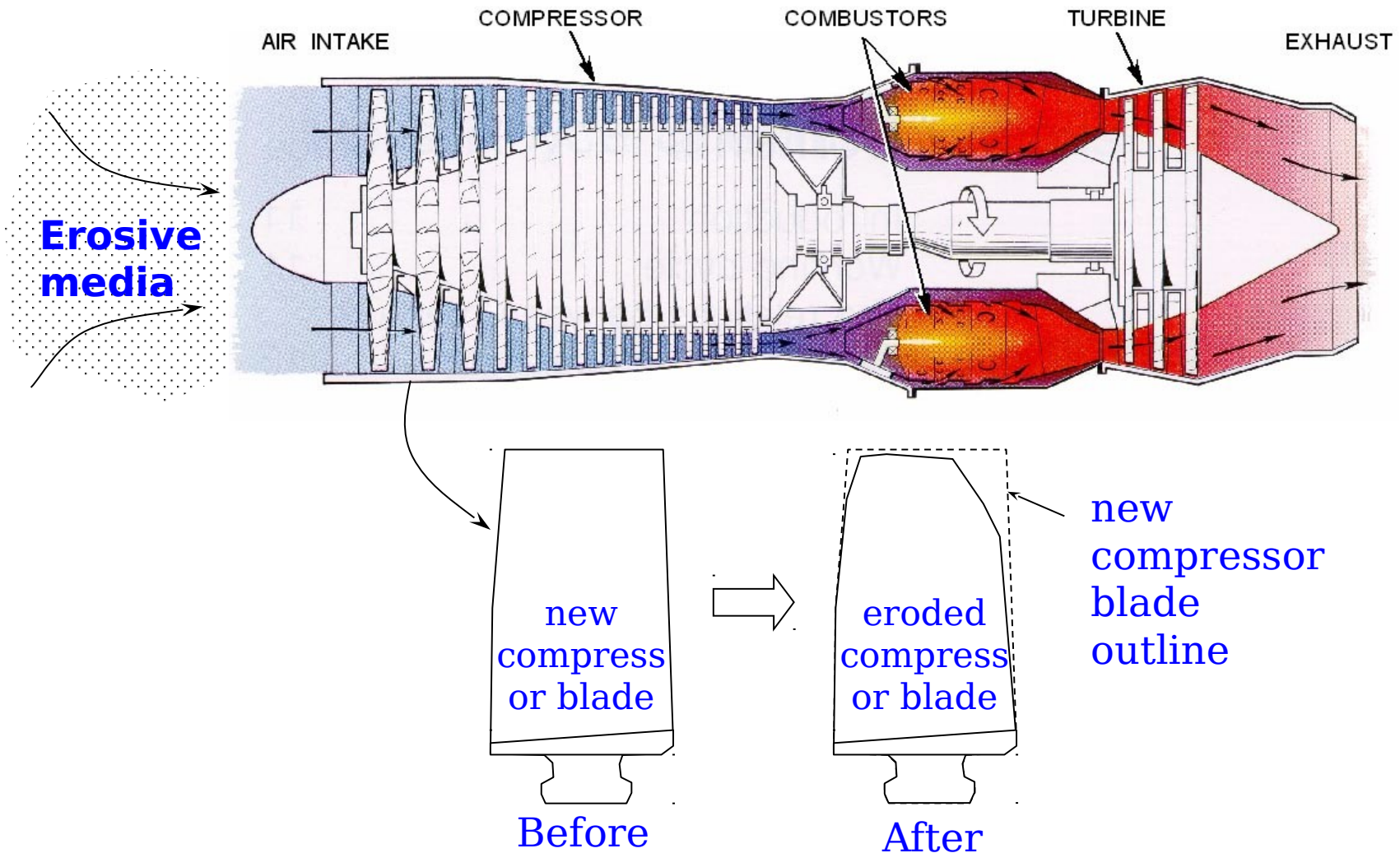


lift operation

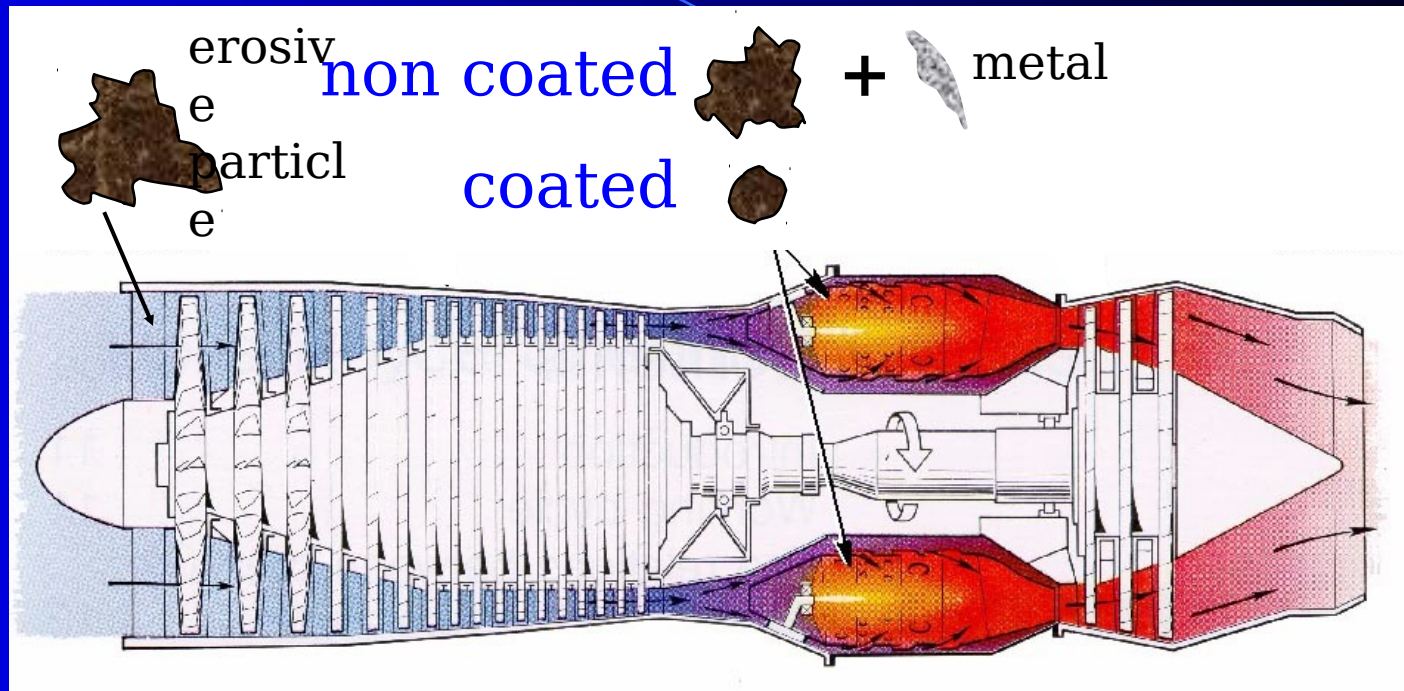


"The Problem"

GAS TURBINE ENGINE



Chain Reaction



- Particle size downstream
 - * Mix of sand & metal
 - * Surface hardness
- Increase in combustor and hot section damage
- Worst case operation at take-off & landing
 - ✈ high speed (air/rotor)
 - ✈ high temperature

Joint Venture

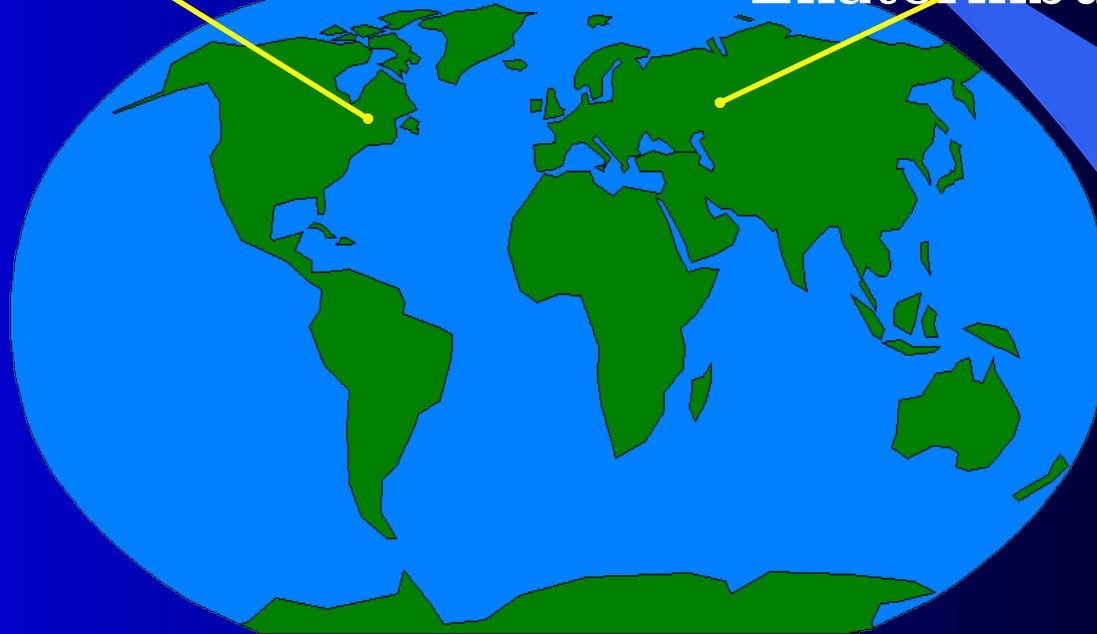
MDS Aero Support
Corporation

Montreal/Ottawa, Canada



Ural Works of Civil
Aviation
(PRAD)

Ekaterinburg, Russia



MDS-PRAD
Technologies Corporation
Joint Venture

MDS-PRAD

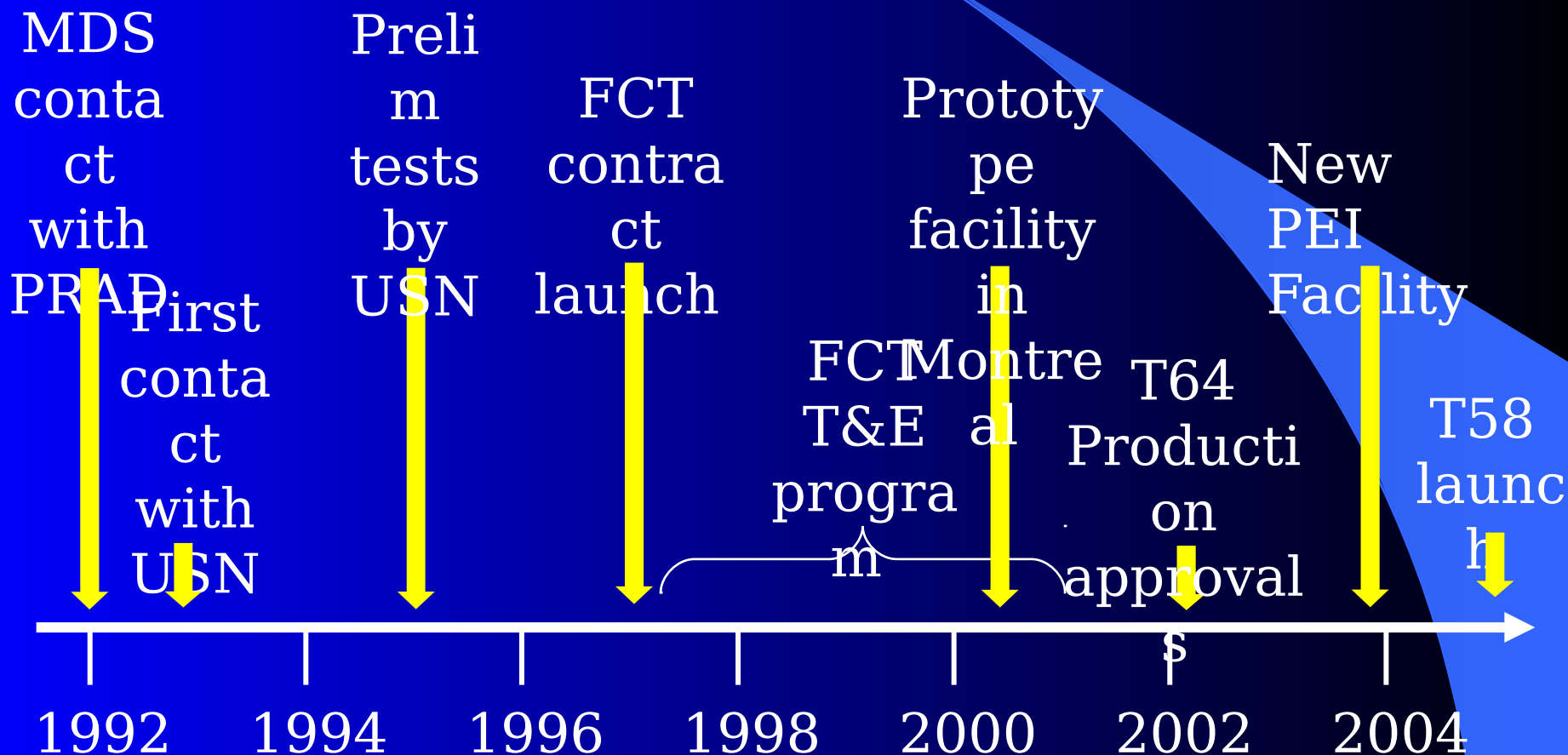
TECHNOLOGIES CORPORATION



Prince Edward Island

Montreal

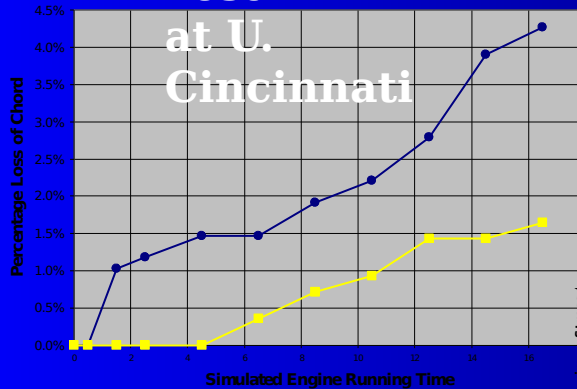
History



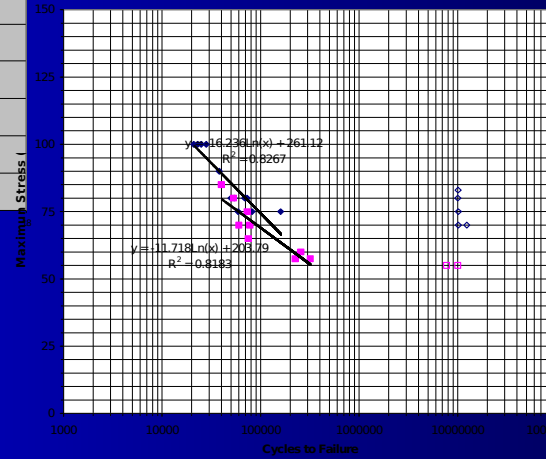
Foreign Comparative Testing T&E Program

Erosion Rig Test

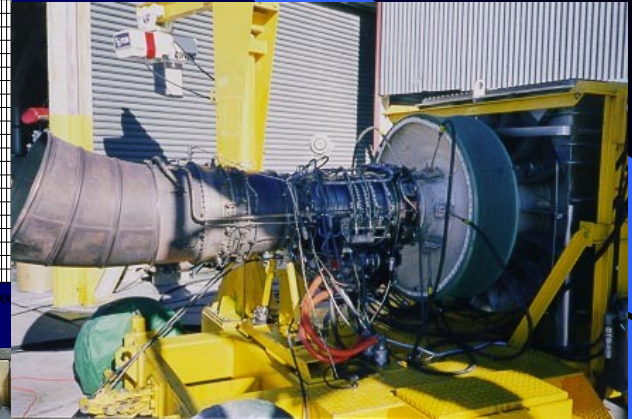
at U.
Cincinnati



High Cycle Fatigue at Metcut Labs



Engine Sand Ingestion At Kirtland AFB

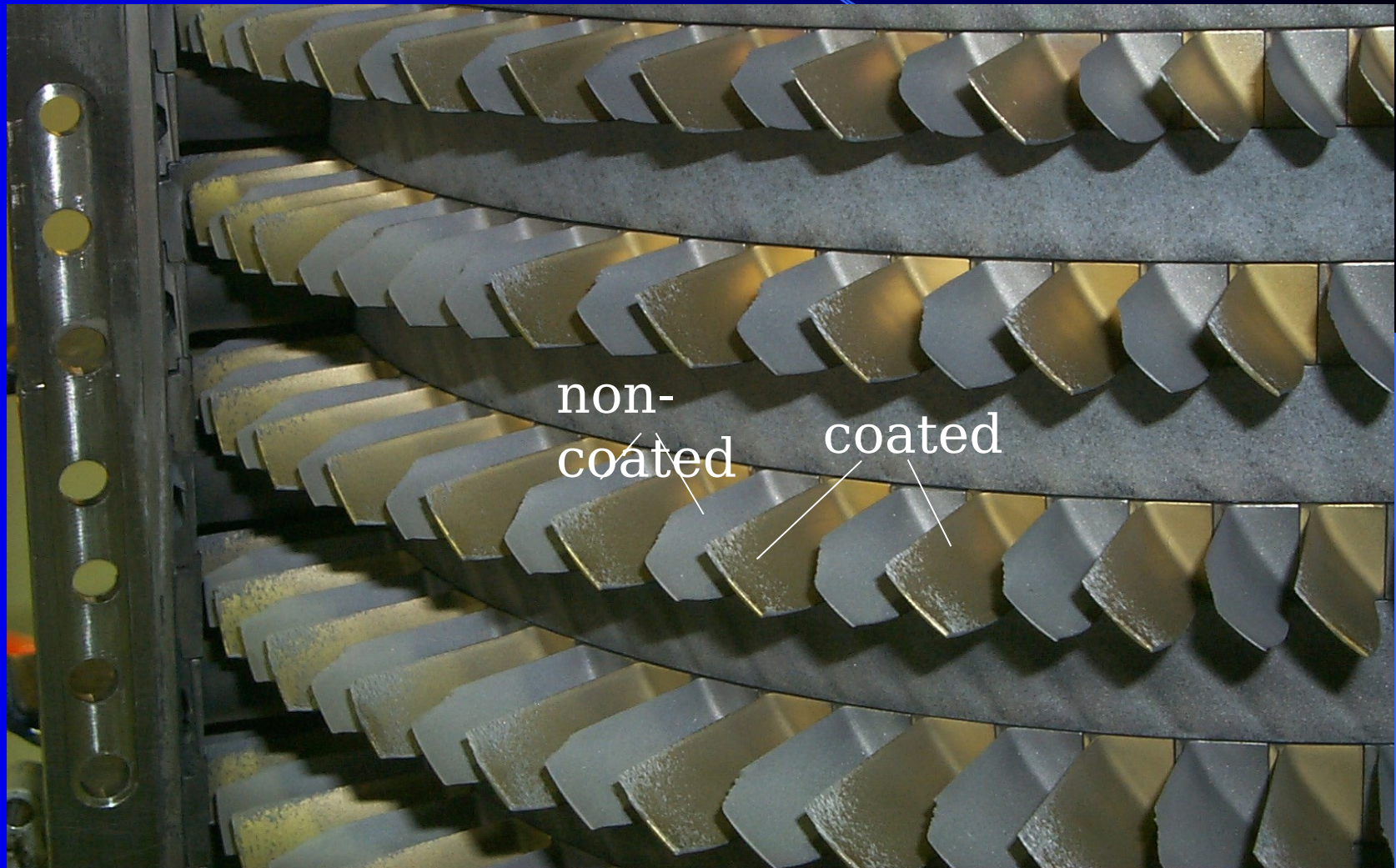


Lead-the-Fleet-Engine at OEF & OIF

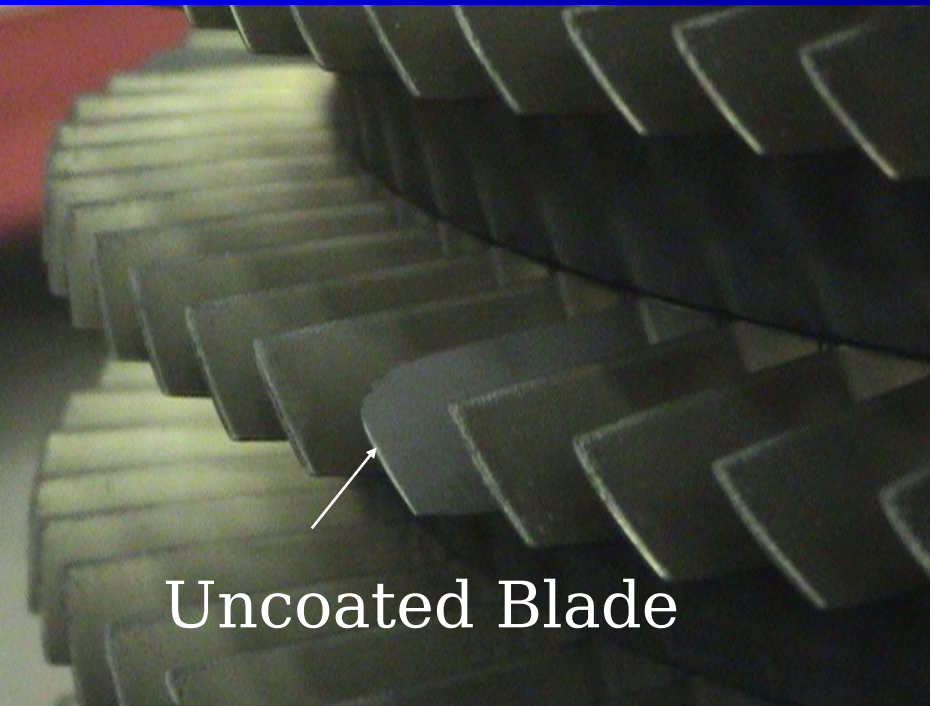


Engine Test Results

T64 Rainbow Compressor
Sand Ingestion Test at Kirtland AFB

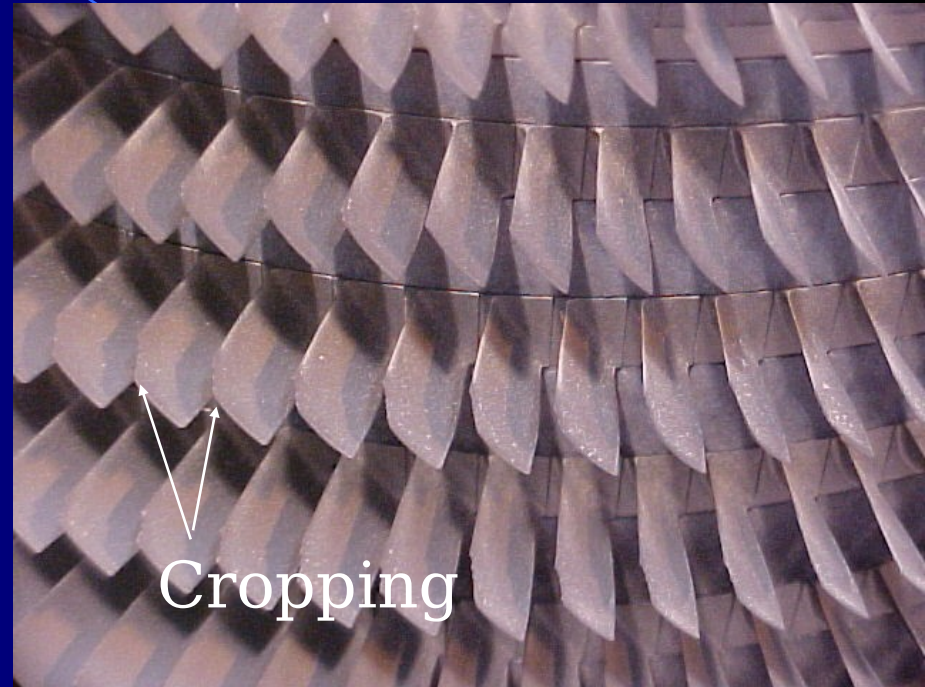


Lead-the-Fleet Engine



Uncoated Blade

**Coated LTFE operated
in
29 Palms, Afghanistan
and Iraq.
378 hours.
200 + hours in OIF.**



Cropping

**Both uncoated engines on same
H53 helicopter as LTFE
removed after 100 + hours.**

***One engine removed for low power and
other removed due to compressor stall***

T64 with ER-7 in OIF

as of 18 February 2005



- T64 ER-7 coated compressors delivery data:
 - * 239 sets delivered to NAVICP from GEAE
 - * 106 RFI engines issued to CH-53 Fleet
 - * 63 engines installed
- T64 ER-7 operational data:
 - * NAVAIR specifically tracking 25 ER-7 coated engines.
 - * Total hours for all ER-7 coated engines accrued ...



9731 hours

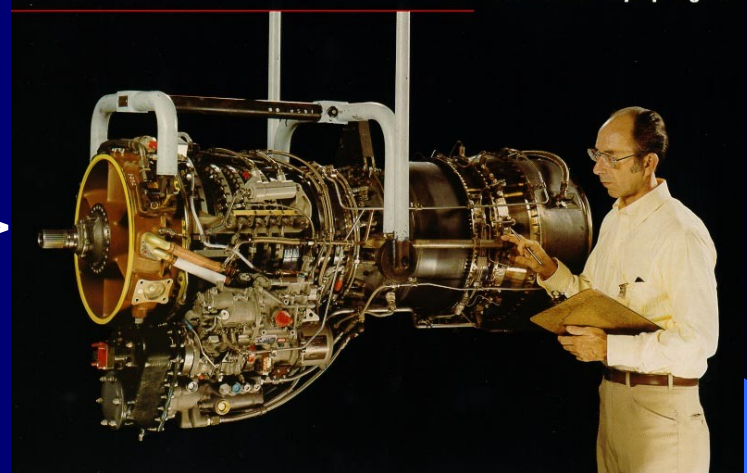
T64 with ER-7 in OIF

as of 18 February 2005



T64 fleet average for
uncoated engines ~ 100
hours

=>



Current high-time ER-7
coated T64 engine at 495
hours

=>



5X LIFE IMPROVEMENT

OIF Operations

as of 18 February 2005

- 35 uncoated T64 engines removed due to low power ☹
- Zero ER-7 coated T64 engines removed due to low power ☹
 - Increase weapon system readiness & availability
 - Decrease logistics support required
 - Decrease overhaul costs
 - Increase flight safety
 - Increase system performance

FLEET AND FLEET SUPPORTERS ARE ☺

T64 Cost Avoidance Realized



- Cost Avoidances in 2004 ~ \$50M
 - Based on:
 - Avoiding 2 overhaul cycles at ~ \$500k / ea.
 - 50 engines operating in field
- 200 Engines delivered by MPT in 2004

• Potential cost avoidance ~ \$200M

Test & Evaluation Program

- NAVAIR-led T&E program completed in 9 months.
Completion = official decision to go into production.
- Sand ingestion test demonstrated coating stopping LE curl erosion.
- Qualified & approved for production
- Production start in March 05
- Ranch



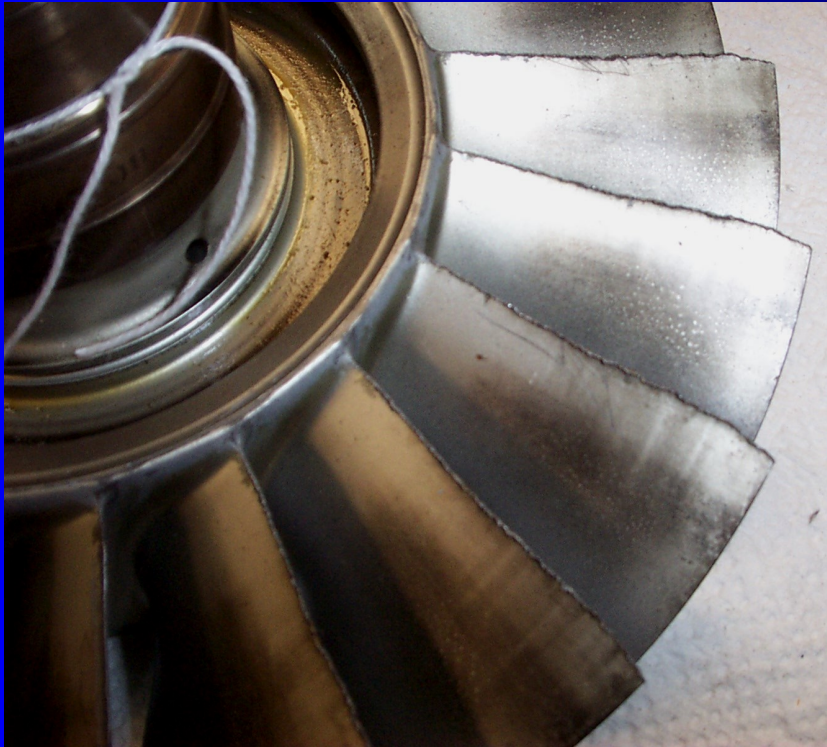
Other Engine Programs



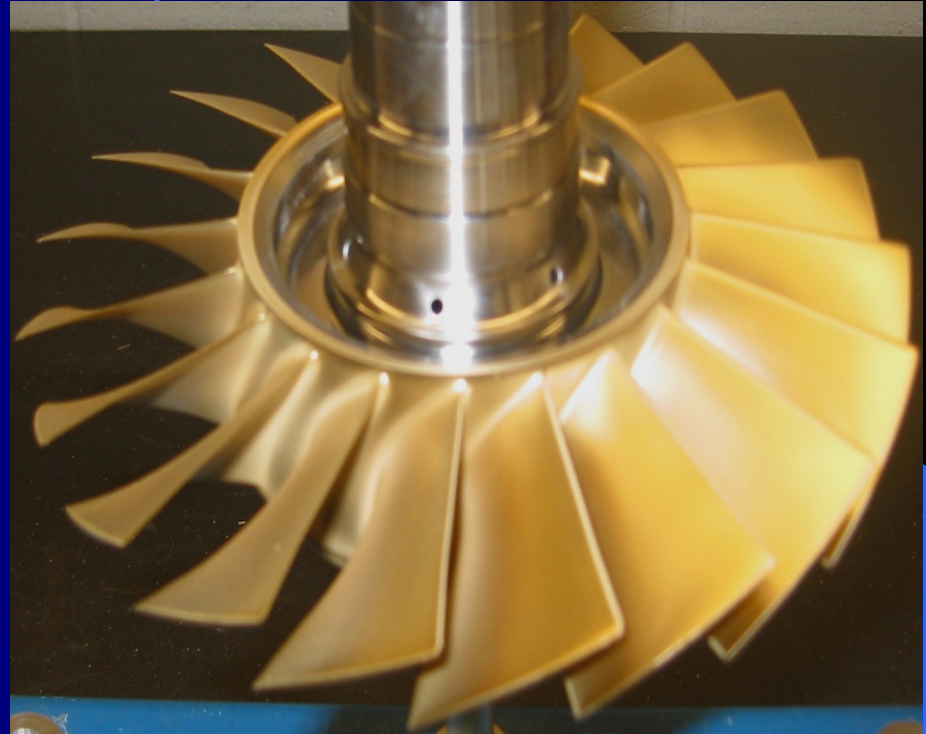
T700 T&E Program



T700 T&E Efforts

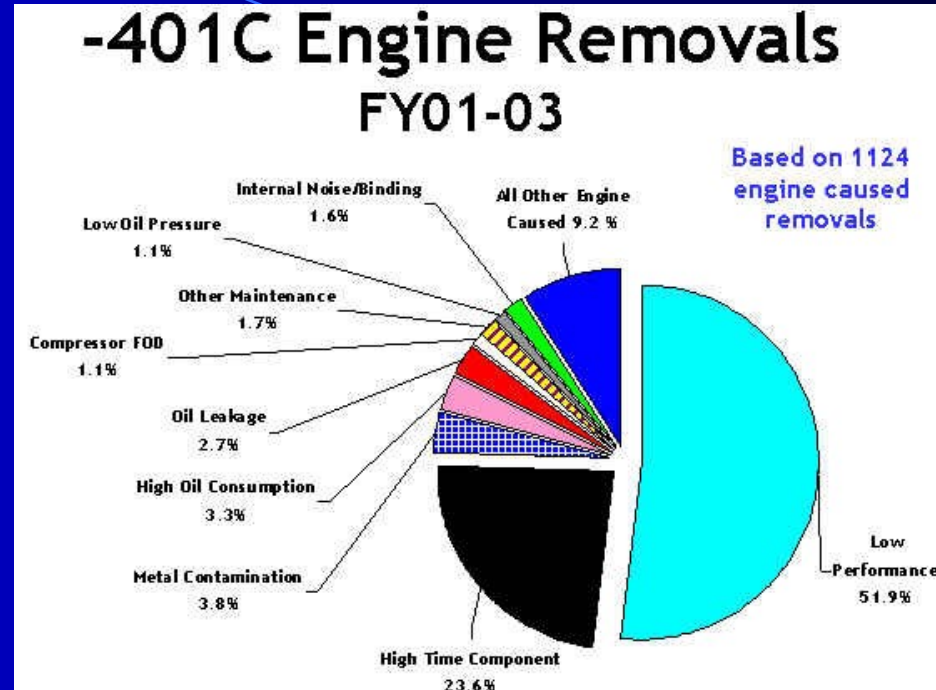


CCAD Sep 2002



Coated 1st Stage Blisk

Goal = Delay LE Curl Erosion
by 1.25 to 1.5 x



Navy/(Army) Experience

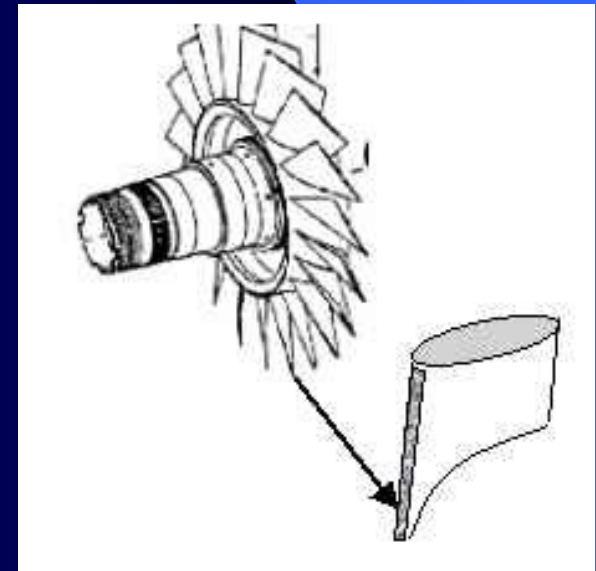
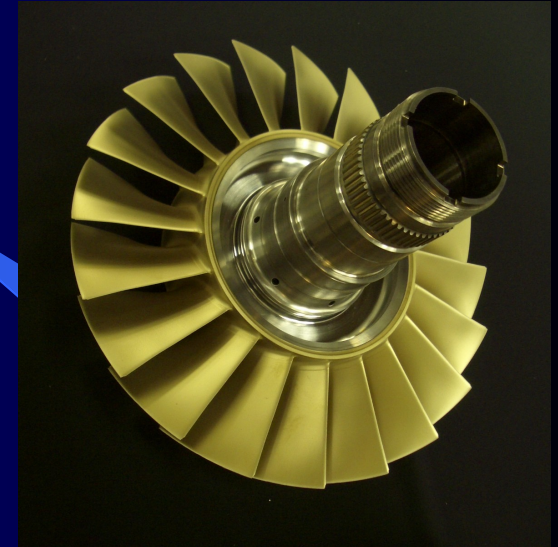
- **Low Power is #1 reason for unscheduled engine removals**
 - ranges from between 50-65% of all removals
- **Navy Time On Wing (TOW) for Low Power removals (FY03):**
 - SH-60B 814 (almost completely sea based)
 - SH-60F 595 (mix of sea and overland ops)
 - HH-60H 399 (majority overland ops)
- **The main contributor to over-all compressor performance loss is S1 Leading Edge (LE) rollover**

Near-term Effort (field within 15-18 months):

1. **Application of ER-7 (TiN) erosion resistant coating to current T700 1st stage blisk configuration.**
 - Currently conducting sand ingestion test on uncoated and coated engines at NAVAIR.

S1 Blisk Redesign Efforts (field within 3 years):

1. **Strengthen airfoil LE by increasing its thickness.**
 - Utilize improved aero design to avoid efficiency loss
 - Goal is 2x improvement in S1 durability.
 - Goal is 50% improvement in TOW for engines removed for low power due to erosion.
2. **Increase strength of airfoil root to allow greater fatigue margin.**
 - Allow greater knock-down margin for future coating considerations
3. **Possible application of erosion/corrosion resistant coating**
 - Further resistance to erosion if cost effective
 - Possible requirement for more durable corrosion





- Engines inducted into depot at 50% power loss.
- ~ 100 engines per month repaired at Anniston Army Depot.
- ~ 60% of airfoils scrapped.



- LE curl on 1st stage blades
- Chord loss erosion & blade thinning erosion other stages.
- Uncoated vs coated engine sand ingestion test required to quantify op benefits.

Other Engine Coating Programs



- T55 for CH-47
 - US Army pursuing FY06 funding support to emulate T58 T&E program.
- T56 for C-130
 - Rolls-Royce recently completed USAF funded CIP to evaluate 13 different erosion / corrosion resistant coatings
 - RR plans on qualifying coating vendor towards end of FY06
- AE1107 for V-22
 - RR conducting fatigue and sand ingestion test of M262 airfoils and complete compressor set.

T&E Efforts

- T&E efforts on various engines has resulted in MPT successfully applying ER-7 coating on numerous material types:
 - * AM350 & AM355
 - * A286
 - * 17-4 PH
 - * Inconel 718
 - * Ti-6-4

2) Wet Blast Process



3) Ultrasonic Clean Process



4) Coating Process DVD

1) & 8) Ship/Receive



6) 100% visual



5) Special Vibro-Treatment (SVT)



7) Metallographic Lab



Mature Production Capability



Production Status



- Eight (8) Automated Coating Machines
 - * meets T64, T58 production plans + 20% overcapacity.
- 450k parts ~ 200 engines coated in 2004.
- PEI facility designed to accommodate 16 machines.



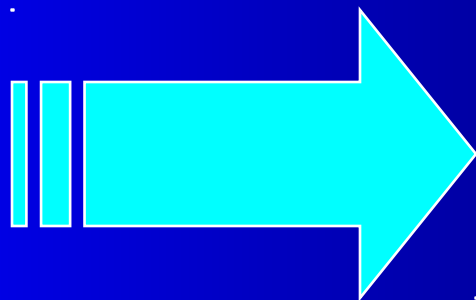
- Future production plans shall assess customer requirements - including establishing coating operations in U.S.

Dedicated R&D Shop

- Montreal facility established as new fast shop concept

=> rapid transition from T&E to production.





End

Coating

Presentation